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Multiple attachment perspectives: the relationship between interpersonal attachment from family and school environments and children's learning engagement

Qi Li[2], Die Wang[3] and Guihua Qin[1*]

Abstract

Objectives Abundant evidence has demonstrated that positive interpersonal relationships promote children's learning engagement. However, most existing studies only focus on the role of one or two attachment relationships, and few studies examine the relationship between multiple positive interpersonal relationships from family and school environments and children's learning engagement. The purpose of this study is to simultaneously examine the effects of father-child and mother–child attachment from the family environment and teacher-student relationship and peer attachment from the school environment on learning engagement of Chinese boys and girls.

Methods Participants ($N = 702$; 51.6% male, $M_{age} = 10.39$, $SD_{age} = 0.49$) were recruited from seven primary schools in Guizhou province, China. Participants completed five self-report questionnaires assessing children's learning engagement, father-child attachment, mother–child attachment, teacher-student relationship and peer attachment.

Results The results displayed that only mother–child attachment and teacher-student relationship significantly predicted boys' learning engagement. In addition, we also found that only teacher-student relationship and peer attachment positively predicted girls' learning engagement.

Conclusions Our findings highlight that teacher-student relationship promotes learning engagement in both boys and girls, and in addition, mother–child attachment from the family environment enhances boys' learning engagement and peer attachment from the school environment promotes girls' learning engagement. This study's results suggest that future attachment-based interventions aimed at contributing to children's academic development should focus on teacher-student relationships for both boys and girls, on mother–child relationships for boys, and on peer relationships for girls.

Keywords Father-child attachment, Mother–child attachment, Peer attachment, Teacher-student relationship, Learning engagement

*Correspondence:
Guihua Qin
qyaqi0220@163.com
Full list of author information is available at the end of the article

Introduction

Learning engagement, an important indicator to measure students' learning process, refers to an active and fulfilling state of learning, which includes three components: behavioral, affective and cognitive engagement [1, 2]. Early learning engagement is strongly associated not only with academic achievement [3], subjective well-being [4] and internalizing and externalizing problem behaviors [5, 6], but also with an individual's personal achievement later in life [7]. Unsurprisingly because learning engagement is a prerequisite for individuals to achieve academic success [8], it has been highly valued worldwide, especially in China, which is rooted in Confucianism, where academic success has become a focus of public attention, as high academic achievement is the key to admission to top universities [9, 10]. Even among primary school students, academic achievement is seen as the main way to obtain a higher social status, which is closely related to future development [11]. Therefore, it is essential to focus on the learning engagement of Chinese elementary school students.

To date, a growing number of researchers have attempted to identify the key factors that promote children's engagement in learning, and some of them have concluded that schools can have an impact on students' academic development by providing interpersonal relationships that meet their basic psychological needs. Among these, teacher-student relationships and peer attachment play an important role in promoting children's learning engagement [12]. Meanwhile, farther afield in the family environment than in the microsystemic school setting, some researchers have also found that warm parent–child attachments provide an emotional harbor for children and motivate students to learn [13, 14]. Notably, most of the existing studies focus solely on the role of one or two of these relationships, and few studies examine children's learning engagement from the perspective of multiple attachment relationships.

In addition, Skinner et al. (2022) expanded on ecosystem theory by suggesting that multiple micro-systems (especially parents, teachers, and peers) have collective effects on individual's learning engagement, and that cumulative coaction and differentiated coaction are two forms of collective effects [15]. Cumulative coaction refers to multiple micro-systems working together to produce the same developmental outcomes; Differentiated Coaction refers to the unique effects of each microsystem on individual development [15, 16]. Researchers have proposed that positive protective factors from the home and school environments cumulatively enhance children's learning engagement [17], but few studies have explored the unique effects of parent–child attachment, teacher-student relationships, and peer attachment on children's learning engagement from a "differentiated coaction". Finally, children's gender should also be considered in exploring the differential effects of multiple attachment relationships on children's learning engagement. At home, fathers and mothers may treat their children differently because of their gender [18]; at school, teacher-student and peer attachment can have different impacts on the development of boys and girls [19]. Therefore, based on the perspective of multiple interpersonal attachment, this study aims to explore the differential effects of father-child attachment, mother–child attachment, teacher-student relationship and peer attachment on boys' and girls' learning engagement, and then to make accurate and practical suggestions for improving children's engagement in learning.

Father-child and mother–child attachment and learning engagement

Attachment is a deep and continuous emotional connection between an individual and significant others in the process of growth [20]. In the family environment, children tend to develop father-child and mother–child attachments with their fathers and mothers, which may affect children's learning engagement [8]. Self-determination theory (SDT) emphasizes the importance of a sense of connectedness, belongingness, and relatedness as basic psychological needs required to initiate and sustain motivation and engagement [21, 22]. According to SDT, a close and sensitive relationship with fathers and mothers fosters a sense of relatedness that in turn supports feelings of self-worth, motivation, and learning engagement [23]. This sense of relatedness is hypothesized to trigger effort, persistence, and participation; to foster interest and enthusiasm; to promote confidence in one's skills [24]. Alternatively, relationships that are characterized by conflict can inhibit engagement and lead to disaffection, diminished self-esteem, and lower amounts of motivation. Previous studies have shown that elementary school students with warmer and more supportive fathers and mothers are more behaviorally engaged and academically motivated [13, 25]. They also perceive themselves as more competent and feel more supported and connected to school than children who have less positive relationships with parents [24].

In addition, father-child and mother–child attachments may have different effects on children's learning engagement. From a developmental perspective of attachment theory, three key points emerge: First, children's attachment relationships with their mothers and their father can be different and complementary, thus being specific to the parent [26, 27]. Second, attachment theory indicates that security and exploration represent two sides of the same attachment coin – parents may serve as a haven

of safety and a trusted companion during exploration. However, subsequent researchers have consistently suggested that mothers and fathers have distinct and complementary attachment roles [28–30]. Finally, mothers are often viewed as safe haven attachment figures [31, 32], whereas fathers are considered as facilitators of children's exploration system [33, 34].

Consistent with attachment theory, in traditional Chinese culture, where "men take care of things outside the family whereas women take care of things inside the family" (*nan zhu wai, nv zhu nei)*, the roles of mothers and fathers as attachment figures are different [35, 36]. Chinese fathers often play the role of playmates in their interactions with their children, encouraging and guiding their children to explore the outside world, cultivating their children's ability to concentrate, and building close father-child attachments with their children [27, 33, 36]. In contrast, Chinese mothers play a more caring role in child rearing; they sensitively take care of their children's daily life and provide an "emotional harbor" to accept and smooth over their children's negative emotions [35, 37]. Furthermore, recent researchers have consistently believed that father-child attachments and mother–child attachment have different effects on children's social-emotional competence [28]. However, it remains to be seen whether father-child attachment and mother–child attachment may have different effects on children's learning engagement.

Teacher-student relationship and peer attachment and learning engagement

According to the ecological model, proximal environmental factors have a direct impact on children's growth and development [38]. Since children's learning engagement mainly occurs in the school environment, the teacher-student relationship and peer attachment in the school environment may affect children's learning engagement. Teacher-student relationship refers to the meaningful emotional connection between teachers and students formed in the long-term interaction [39]. Peer attachment is a stable emotional connection that develops over time as an individual interacts with peers [40]. At present, a large number of studies have confirmed the significant correlation between teacher-student relationship and children's learning engagement respectively [41, 42]. For example, a meta-analysis by Roorda et al. (2017) found that teacher-student relationships have a direct impact on children's engagement in learning [41]. In addition, the positive predictive effect of peer relationship on learning engagement has been gradually verified [43, 44]. For example, Yang et al. (2018) found that peer attachment has a persistent positive predictive effect on children's learning engagement, and compared with other educational stages, peer attachment in primary school is more closely related to students' learning engagement [44]. However, few studies have simultaneously examined the effects of father-child attachment, mother–child attachment, teacher-student relationship, and peer attachment on children's learning engagement, and further explored which relationship has a greater impact on children's engagement in learning under the multiple attachment perspective.

Importantly, child gender, as an immutable factor, may affect the relationship between multiple positive relationships and learning engagement. Gender role theory suggests that parents treat sons and daughters differently and tend to form differentiated parenting patterns [45]. For example, parents predominantly adopt play-based approaches with sons, encouraging exploratory behaviors and autonomy development through structured play activities, while simultaneously emphasizing achievement motivation [46]. In contrast, parents tend to employ emotion-focused socialization strategies with daughters, fostering emotional competence through affective communication and encouraging emotional expression [47], 18]. These differential interaction patterns are theorized to engender variations in parent–child attachment quality, which may subsequently exert gender-specific influences on children's learning engagement. Recent research has found that father-adolescent conflict was negatively related to boys' academic engagement and mother-adolescent conflict was negatively related to girls' academic engagement [48]. Similarly, the importance and supportive role of teacher-student relationships and peer attachment differ for boys' and girls' engagement in learning. According to the ethics of care theory, girls have higher role differentiation ability, that is, the cognitive-emotional ability to adaptively transform behavior scripts in the social environment [49], which may strengthen the link between positive interpersonal relationships in the school environment and girls' learning engagement. Previous research has shown that teacher-student relationships are more likely to promote girls' rather than boys' school engagement and sustain academic success [50, 51]. Therefore, father-child attachment, mother–child attachment, teacher-student relationship and peer attachment may have gender differences in children's learning engagement.

Current study

Using structural equation modeling (SEM), this study aimed to simultaneously explore the relationships between father-child attachment, mother–child attachment, teacher-student relationship, and peer attachment and Chinese children's learning engagement. Considering that child's age and SES may affect the relationship

between the above variables [32], we controlled for child's age and SES in the model. We hypothesized that father-child attachment, mother–child attachment, teacher-student relationship, and peer attachment can significantly positively predict children's learning engagement. In addition, given the higher role differentiation ability of girls [49], we further hypothesize that teacher-student relationships and peer attachment in the school environment may be more strongly associated with girls' learning engagement.

Methods

Participants

A total of 702 children aged 10–12 years were recruited from seven primary schools in Guizhou Province, China. The average age of the children was 10.39 ($SD = 0.49$; 362 boys and 340 girls). We tested the socioeconomic status with a question: "Please assess your family's socioeconomic status from 1 (*very poor*) to 10 (*very rich*) based on your province's economic situation". The majority (62.5%) had a middle or higher socioeconomic status. Missing values were handled through the SPSS Missing Values Analysis. Items from the questionnaires had no missing values or had less than 1% of missing values. Little's missing completely at random (MCAR) test was conducted to test whether the data were MCAR. A non-significant result was obtained ($\chi^2/df = 1.01$, $p = 0.44$), indicating that MCAR may be inferred.

Procedures

All children participated voluntarily and with the school's consent, the teacher and the participant's guardian. At the beginning of the experiment, the children completed a set of questionnaires under the guidance of a research assistant in a quiet classroom (two research assistants per classroom). Upon completion, the participants were given small gifts for their participation. This study was approved by the Institutional Review Board (IRB) of Suzhou University of Science and Technology (Approval No. 2014USTS060).

Measures

Student learning engagement

Student learning engagement was assessed by using the Student Learning Engagement Questionnaire [52]. It has been previously adapted to the student population in a Chinese cultural context [53]. This 16 items scale comprises three dimensions: emotional engagement, behavior engagement and cognitive engagement. Participants were asked to assess the agreement with each item using a 5-point Likert scale from 1 (*completely disagree*) to 5 (*completely agree*). Scores were summed across items, and higher scores indicated more learning engagement. The Cronbach's α coefficients for these 16 items were 0.84.

Father-child and mother–child attachment

The father-child and mother–child attachment were assessed using the parent subscales of the "Inventory of Parent and Peer Attachments" (IPPA) [40]. The IPPA has been demonstrated to be a valid measure of father-child and mother–child attachment quality for Chinese children and have high test–retest reliability and internal consistency [54]. It consists of 15 items assessing the extent of trust, communication and alienation from each of the attachment figures, with parallel wordings of items for assessing relationships with mothers and fathers. All items are rated on a five-point frequency response scale ranging from 1 (*almost never*) to 5 (*almost always*). Add up the scores of "trust" and "communication" then subtract the "alienation" to get the total score of individual attachment quality. Cronbach's alpha (α) for father-child attachment was 0.88, and the Cronbach's alpha (α) for mother–child attachment was 0.80.

Peer attachment

The peer attachment was assessed using the peer subscale of the "Inventory of Parent and Peer Attachments" (IPPA) [40]. Previous research indicates the IPPA has proven to be a reliable and valid measurement peer attachment quality in Mainland China [19]. The questionnaire contains 25 items divided into three dimensions: trust, communication and alienation. All items are rated on a five-point frequency response scale ranging from 1 (*almost never*) to 5 (*almost always*). Add up the scores of "trust" and "communication" then subtract the "alienation" to get the total score of peer attachment quality. Cronbach's alphas (α) for peer attachment was 0.85.

Teacher-student relationship

Teacher-student relationship quality was measured using the Teacher-Student Relationship Instrument (TSRI), which was originally developed by Pianta [55]. Previous research indicates the TSRI has proven to be a reliable and valid measurement in Mainland China [19]. This 18-item instrument assesses students' perceptions of three features of their relationships with their teachers: closeness, positive reactivity and conflict. Participants rated items in terms of how applicable each statement was to their relationships with their current teachers. Responses ranged from 1 (*definitely does not apply*) to 5 (*definitely applies*). Scores were computed by averaging items. The conflict subscales were reversed so that high scores represent a positive relationship characterised by

trust, warmth and low conflict. The Cronbach's α coefficients for these 18 items were 0.75.

Control of common method variance

Considering that all questionnaire measures in this study were self-reported by the children, we minimized the effects of common method variance through procedural remedies, such as using well-established scales and setting some polygraph items [56]. Additionally, we employed Harman's single-factor test, a widely used method, to detect the threat of common method variance [57]. We performed factor analysis on all items, and found that 18 factors with eigenvalues greater than one were extracted, with the first factor accounting for 25.00% of the variance (less than 40%). These results suggest that common method variance did not appear to be a problem in this study.

Analysis

All analyses were performed using SPSS Version 25.0 and Mplus Version 8.0. The Mean (M) means, Standard Deviation (SD) standard deviations and Pearson's correlations of key variables were conducted with SPSS 25.0 and Mplus 8.0 was used to verify the hypothesized model by building a structural equation modeling (SEM). Missing data were handled using Expectation Maximization (EM) [58]. The fit of the model was analyzed according to the ratio of chi-square (χ^2) and the degrees of freedom, the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean squared error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Indicators of good fit were considered values of χ^2/df of less than 3.0, values of CFI and TLI greater than 0.90, and RMSEA and SRMR lower than 0.08 [59].

Results

Descriptive statistics and correlations

Table 1 presents the means, standard deviations, correlations and the results of the independent sample t-test for all variables. Correlation analysis showed that apart from age, father-child attachment, mother–child attachment, teacher-student relationship, peer attachment, family socioeconomic status and learning engagement were significantly correlated in both boys and girls. In addition, the results of the independent samples t-test indicated that girls scored significantly higher than boys on all variables except father-child attachment.

Multiple attachment relationships and children's learning engagement

Firstly, we examined the impact of father-child attachment, mother–child attachment, teacher-student relationship and peer attachment on boys' learning engagement, after controlling for child's age and SES. The model (see Fig. 1) was a saturated model provided a good fit for the data, $\chi^2(8) = 3.01$; CFI = 0.911; TLI = 0.933; RMSEA = 0.07; SRMR = 0.07. As Fig. 1 shows, mother–child attachment and teacher-student relationship positively predicted boys' learning engagement ($\beta = 0.24$, $p < 0.001$, a medium effect size; $\beta = 0.40$, $p < 0.001$, a large effect size); However, there was no significant correlation between father-child attachment/peer attachment and boys' learning engagement ($\beta = 0.02$, $p > 0.05$, a small effect size; $\beta = 0.10$, $p > 0.05$, a small effect size).

Second, we also examined the impact of father-child attachment, mother–child attachment, teacher-student relationship and peer attachment on girls' learning engagement, after controlling for child's age and SES. The model (see Fig. 2) was a saturated model provided a good

Table 1 Descriptive statistics and correlation analysis of study variables

	1	2	3	4	5	6	7	Boys (*M* ± *SD*)	Girls (*M* ± *SD*)	*t*	Cohen's *d*
FCA	1	0.52***	0.36***	0.38***	0.35***	0.16***	-0.07	21.04 ± 10.55	21.43 ± 10.98	-0.48	-0.04
MCA	0.51***	1	0.46***	0.47***	0.42***	0.13***	-0.04	22.07 ± 9.82	23.62 ± 9.97	-2.07*	-0.16
PA	0.32***	0.51***	1	0.58***	0.50***	0.08	0.03	43.13 ± 13.91	45.76 ± 14.21	-2.48*	-0.19
TSR	0.35***	0.45***	0.48***	1	0.59***	0.18***	-0.002	32.71 ± 11.26	35.64 ± 12.04	-3.33**	-0.25
LE	0.31***	0.49***	0.43***	0.56***	1	0.12**	0.02	56.36 ± 13.19	58.17 ± 12.34	-1.88†	-0.14
SES	0.19***	0.22***	0.17***	0.13**	0.16***	1	0.02	6.18 ± 1.86	6.60 ± 1.94	-2.91**	-0.22
Age	-0.01	0.04	0.05	0.02	0.11**	-0.1	1	10.44 ± 0.51	10.33 ± 0.47	2.76**	0.22

Correlations in top of diagonal are for girls, in bottom for boys

FCA Father-child attachment, *MCA* Mother–child attachment, *PA* Peer attachment, *TSR* Teacher-student relationship, *LE* Learning engagement, *SES* Socioeconomic status

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

† $p < 0.10$

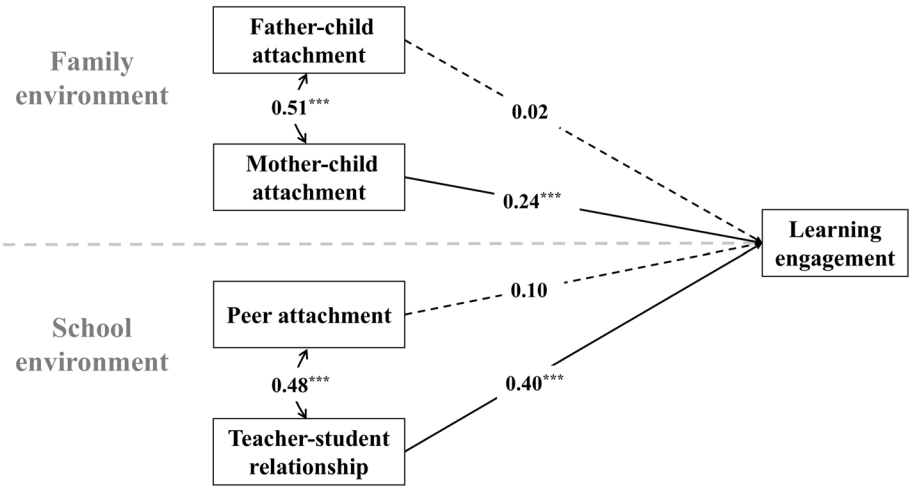

Fig. 1 The model to evaluate the relationship between interpersonal attachment from family and school environments and children's learning engagement in boys, after controlling for child's age and SES. Note. All the coefficients are standardized estimates. ***$p < 0.001$

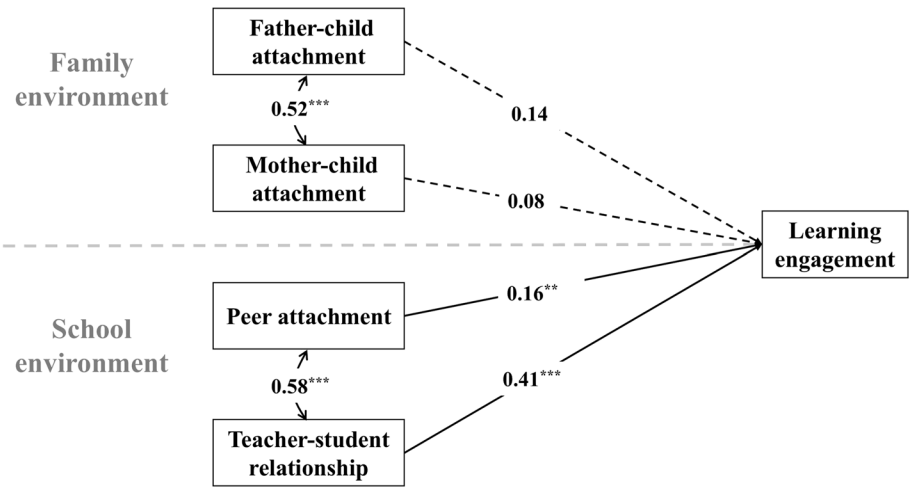

Fig. 2 The model to evaluate the relationship between interpersonal attachment from family and school environments and children's learning engagement in girls, after controlling for child's age and SES. Note. All the coefficients are standardized estimates. ***$p < 0.001$

fit for the data, $\chi^2(8) = 2.33$; CFI = 0.938; TLI = 0.953; RMSEA = 0.06; SRMR = 0.06. Results revealed that mother–child attachment and father-child attachment were not significantly related to girls' learning engagement (β = 0.11, $p > 0.05$, a small effect size; β = 0.07, $p > 0.05$, a small effect size); However, the teacher-student relationship and peer attachment positively predicted girls' learning engagement (β = 0.19, $p < 0.01$, a small effect size; β = 0.40, $p < 0.001$, a large effect size).

Besides, we further employed multi-group structural equation modeling and examined group differences using Wald chi-square tests. Results indicated no significant gender differences in the association between teacher-student relationships and learning engagement (Wald $\chi^2 = 0.31$, $df = 1$, $p > 0.05$) or between father-child attachment and learning engagement (Wald $\chi^2 = 0.38$, $df = 1$, $p > 0.05$) when comparing boys and girls. However, significant gender differences were observed in the associations of mother–child attachment (Wald $\chi^2 = 4.31$, $df = 1$, $p < 0.05$) and peer attachment (Wald $\chi^2 = 3.92$, $df = 1$, $p < 0.05$) with learning engagement.

Discussion

The purpose of this study was to simultaneously explore the relationship between father-child attachment, mother–child attachment from the family environment

and teacher-student relationship and peer attachment from the school environment with Chinese children's learning engagement. The results showed that mother–child attachment from the family environment and teacher-student relationships in the school environment were found to be associated with boys' learning engagement, while only teacher-student relationships and peer attachment in the school environment were associated with girls' learning engagement. These gender-specific patterns offer novel empirical evidence regarding the ecological mechanisms of attachment relationships, though their causal pathways require rigorous validation through longitudinal designs. By constructing a dual-context analytical framework encompassing familial and scholastic environments, this research revealing the different effects of multiple interpersonal attachment relationships on children's learning engagement, thus expanding the prior research. In addition, we identified notable differences between Chinese boys and girls in how multiple interpersonal relationships relate to their learning engagement, a finding that represents another key contribution of this study. Notably, the external validity of these results needs to be confirmed and expanded by cross-cultural studies.

Multiple attachment relationships and children's learning engagement

Our study found that mother–child attachment and teacher-student relationship positively are positively associated with boys' learning engagement. Although this result was found only in boys, it is still partially consistent with previous research that close relationships established between children and significant adults contribute to children's academic development [25]. Our results also partially supported the self-determination theory [21, 23]. Boys' close and sensitive relationships with their mothers and teachers fostered a sense of belonging, which in turn supported a sense of self-worth, confidence and persistence, elevated motivation and engagement in learning [24, 25]. Specifically, good mother–child attachments promote the development of boys' sense of security [60], which are associated with greater engagement and interest in learning [61]. In contrast, strained, conflicted, or rejecting mother–child relationships are associated with disengagement and maladaptive attitudes toward school [62]. Similarly, children with good teacher-student relationships are more motivated to learn, promote participation in the classroom, and are more engaged in learning-related activities [13, 63].

We also found that only teacher-student relationship and peer attachment are positively associated with girls' learning engagement. This result partially supports the ecological model that proximal environmental factors have a direct impact on children's—particularly girls'—growth and development [38]. After entering the school, the school life is more than the family life, the emotional connection between children and peers is increasingly profound, and the attachment focus is gradually shifting from parents to teachers. Children who have a positive teacher-student relationship feel supported and cared for by their teachers, resulting in a sense of belonging to the school, which helps to motivate them to learn, promotes classroom participation, and is more likely to engage in learning-related activities [13, 63]. On the other hand, children with good peer attachment are more likely to receive help from their peers during the learning process, especially when facing learning difficulties, and support from peers may alleviate negative academic emotions and maintain a high level of engagement in learning [14]. Also, when students have friends and feel socially connected and supported at school, this can motivate students to get involved in school work and extracurricular activities [14, 64]. However, we found the positive association between peer relationships and learning engagement exclusively among girls. More crucially, we observed gender differences in how multiple attachment relationships within family and school environments correlate with children's learning engagement. Specifically, while boys' engagement was predominantly associated with adult–child relationships, girls' engagement demonstrated stronger ties to teacher-student and peer dynamics within school-based relational contexts. The following section systematically examines these gender-specific mechanisms.

Gender differences in multiple attachment relationships and learning engagement

We noted that girls' learning engagement was influenced only by teacher-student relationships and peer attachments in the school environment, and father-child and mother–child attachments in the family environment are minimally affected. Comparatively, boys' learning engagement was influenced by mother–child attachment in the family environment and teacher-student relationships in the school environment, while father-child attachment and peer attachment had negligible effects. The results partially support the previous theoretical hypothesis that positive interpersonal relationships from home and school environments have a unique role in children's engagement in learning [15, 16]. The results also support the ethics of care theory, which suggests that girls are more capable than boys of distinguishing the multiple roles they play and demonstrating role-appropriate behavior [49]. This ability contributes to their positive interpersonal relationships within the school environment, which in turn promotes their engagement in learning as students. However, for boys, who are less able to

distinguish roles—with fathers acting as playmates at home and peers serving as playmates at school—good father-child attachment or peer attachment can promote school adjustment and mental health but has little effect on academic engagement [18, 32].

Importantly, this study found that the father-child attachment had little effect on children's learning engagement in either boys or girls. This may be because under the traditional Chinese culture, Chinese fathers are more providers of family economy [32], less involved in raising children, and rarely communicate and interact with their children in academic development. In contrast, the teacher-student relationship has the greatest impact on children's engagement in learning among both boys and girls. This result is consistent with the fact that China, which is rooted in Confucianism and emphasizes *"Zun shi zhong dao"*, teaches children to respect their teachers from an early age, and that children consciously obey teachers' instructions in the school environment [65, 66]. It is not surprising that the teacher-student relationship has the strongest effect on children's learning engagement. This result reminds us that teachers should show warm, sensitive, caring and other positive characteristics, and actively interact with children, and establish a strong warm teacher-student relationship in this process, which is an effective measure to promote children's learning engagement.

Besides, Chinese boy' learning engagement may be more dependent on mother–child attachment, while girls' learning engagement may be more dependent on peer attachment, which may be because boys and girls will form different attachment strategies in different socialization processes with the development of gender cognition [67]. Boys may be more likely to draw on a strong bond with their mother for security and learning support, while girls may develop social skills and motivation to learn through interaction with peers [68]. Such patterns are culturally embedded in China's Confucian-informed family role divisions: within an academic achievement-oriented cultural context, mothers assume primary caregiving responsibilities as "academic supervisors" for sons, whereas fathers predominantly provide financial support [32, 68]. Coupled with residual son-preference cultural norms, mothers exhibit significantly higher academic involvement with sons than daughters, fostering boys' rather than girls' dependency on maternal guidance [69]. For girls, socialized earlier into relational interdependence [70], peer attachment relationships are often viewed as another important source of social and emotional support, and peer attachment in the school environment has a positive impact on girls', rather than boys', engagement in learning, such as increasing their motivation, effort and cooperation in learning [8]. These findings suggest that interventions aimed at improving students' learning engagement should consider the potential differences in attachment dynamics between boys and girls. While improving the quality of teacher-student relationships remains a universal goal, targeted approaches may also be beneficial. For instance, interventions for boys could focus on enhancing the quality of mother–child attachment, given its apparent significance for their learning engagement. For girls, fostering positive peer relationships may be particularly impactful.

Limitations and implications

Some limitations of this study must be mentioned. First, all measures in this study were based on children's self-reports. Although the use of same-child self-reports is generally associated with a high degree of reliability, there may be a consistency bias in the reports of the same observer (child) across different questionnaires, which may also lead to some of the correlations being overstated. In further research, using multiple data collection methods (e.g., parent report or teacher report) to minimize these potential biases. Furthermore, this study only used a single SES measure, which might be subjective. Future studies could incorporate more objective indicators, such as parents' education level and income level, to enable a more comprehensive investigation. In addition, all samples were from Chinese families, and the findings were specific to the Chinese educational context and cultural environment. Future research could explore the relationship between multiple attachment relationships and children's learning engagement in different cultural contexts. Finally, our design was cross-sectional, which limits the causal interpretation of the directionality of the findings. Future research could employ a mixed-methods approach to further explore these relationships. On the one hand, longitudinal or cross-lagged research designs could help clarify the temporal and causal dynamics between variables. On the other hand, qualitative methods, such as in-depth interviews with teachers, parents, and students, could provide richer insights into the underlying mechanisms and contextual factors that influence learning engagement and attachment relationships.

Despite these limitations, the present study was based on multiple attachment perspectives and simultaneously explored the unique effects of father-child and mother–child attachment from the family environment, teacher-student relationship and peer attachment from the school environment on Chinese boys' and girls' learning engagement. These findings support and extend self-determination theory and ecosystem theory. In addition, the study found that teacher-student relationships from the school environment had a greater impact on boys' and girls' learning engagement than other positive

interpersonal relationships, which extends the limitations of previous research. Finally, our findings emphasize that mother–child attachment from the family environment promotes boys' learning engagement and peer attachment from the school environment promotes girls' learning engagement, which provides actionable recommendations for precise interventions and promotion of children's engagement in learning.

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Authors' contributions
Guihua Qin collected and analyzed the date. Qi LI and Die Wang wrote the main manuscript text. Qi Li prepared all figures in the manuscript. all authors reviewed the manuscript.

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Data availability
The dataset used in this study is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Institutional Review Board (IRB) of Suzhou University of Science and Technology (Approval No. 2014USTS060). Since all participants were minors (under the age of 16), written informed consent was obtained from their parents or legal guardians before their participation in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]School of Education, Suzhou University of Science and Technology, Suzhou 215600, China. [2]School of Psychology, Zhejiang Normal University, Jinhua 321004, China. [3]Faculty of Psychology, Southwest University, Chongqing 400799, China.

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